NEEDED: Teachers to Encourage Girls in Math, Science, and Technology

by **Sally M. Reis** and **Carol Graham**

"If female underachievement is best measured by the many talented women in our society who look back at their lives with feelings of regret, it then becomes our responsibility to help future generations of gifted and talented females before they, too, underachieve."

—Sally Reis (2002, p. 132)

"Girls they wanna have fu-un, oh, girls just wanna have fun . . ."

The words of Cyndi Lauper energize the atmosphere as Frisbees begin to fly and a group of fifth-grade girls from Crabapple Crossing Elementary School file into the TAG resource room to face a fun-loving group of enthusiastic young scientists from Milton High School of Fulton County Schools in Georgia. One fifth grader leaps into the air to capture the first Frisbee, which displays the statement "Physics is fun!" Another girl repeats the message on the next Frisbee to her friend, "Technology is fun!" With a confluence of energy and expectation, the mayhem and madness yields a serious message: Young gifted women from Milton High School believe that women of the 21st century must not be overlooked in fields in which women continue to be invisible, and their proposal for correcting this problem is through a networking of gifted girls and mentorship. The networking began in this classroom and extended beyond tomorrow into the network of the World Wide Web.

The person who developed this program, Carol Graham (grahamc@ fulton.k12.ga.us), who teaches academically talented students in Milton High School, watched with delight as the academically talented senior high school girls scanned faces to find the student each had prepared to mentor for the last several months. This exciting program was created during the last few years, when a group of administrators, teachers, and a technology teaching assistant worked together to develop a mentorship program involving 12 high school girls and their elementary counterparts. The purpose of the program, which the girls named "Science and Techknow Chicks Coming Together," was to encourage more academically talented girls to pursue math, science, and especially technology.

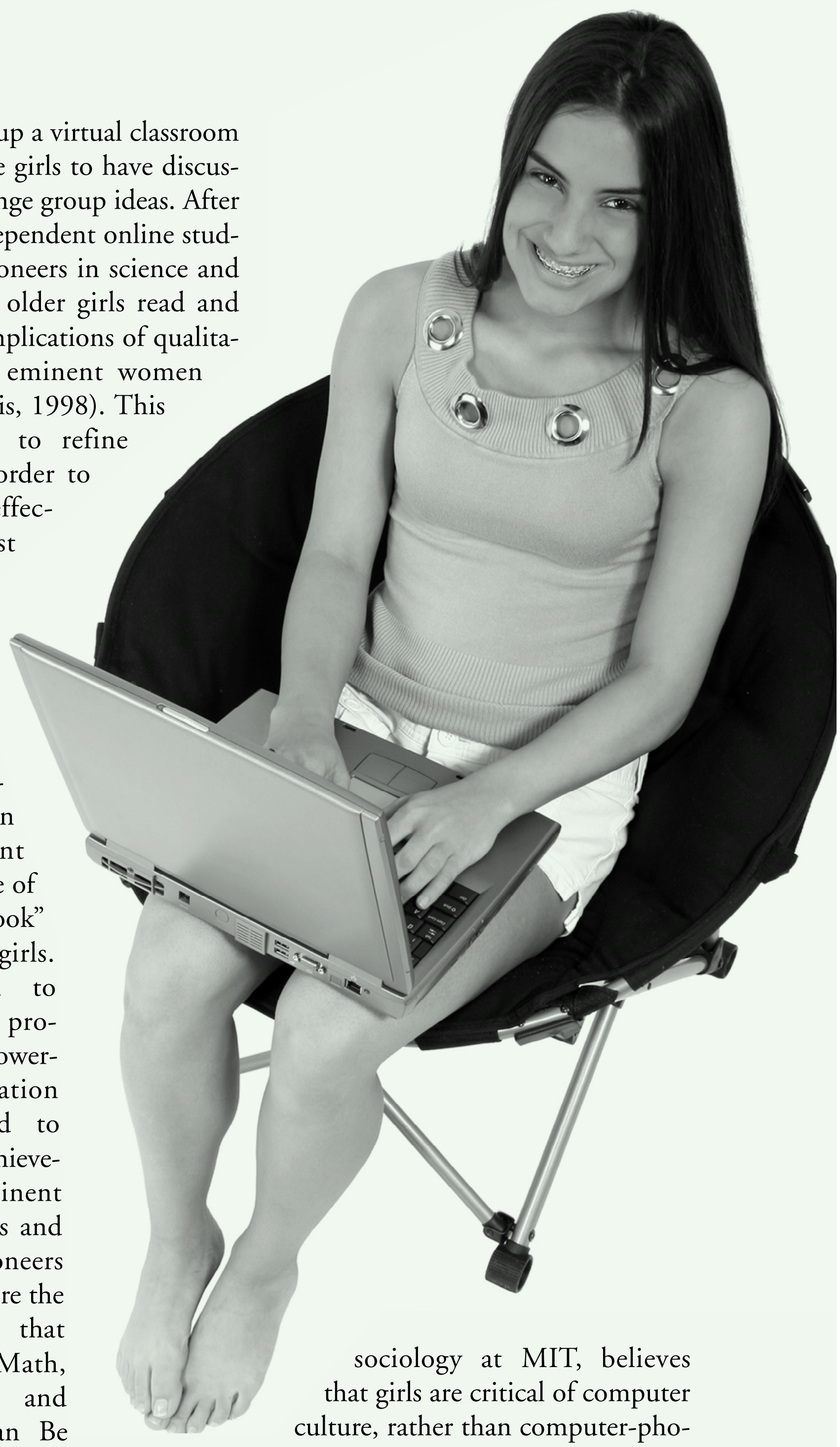
The interests of the high school girls in this cause were peaked during a seminar led by Mary Ellen Burrell, Carol Graham, and Jeri Groves in which the focus was on women in math, science, and technology. In the seminar, the girls and their teachers explored areas such as gender equity in textbooks, the dilemma of juggling multiple career and personal roles, cultural attitudes affecting girls in technology classes, and the barriers faced by women who select careers in these areas. The girls explored Web sites, such as Distinguished Women of Past and Present (http://www.distinguishedwomen.com), to learn about some of the challenges faced by women with interests in computer science and engineering. They found interesting facts, links devoted to female techno-pioneers, and compelling biographies of inspirational women, from Rosalind Franklin to Ada Augusta Lovelace.

Each of the senior high girls conducted advanced Web-based research about a pioneer in technology, sci-

ence, or math, focusing on characteristics of these women and the patterns they found across the different women. They found both interesting activities and case studies about women and technology from professional associations such as The Computer Research Association's Committee on the Status of Women in Computing Research (http://www.cra.org/Activities/craw), which is funded by the National Science Foundation. This group is dedicated to increasing the number of women participating in computer science and engineering research and education at all levels. The girls also found information about the Ada Project (http://tap. mills.edu), a clearinghouse for information and resources relating to women and computing, as well as information about women who play a leadership role in technology (http://www.cio.com/archive/070199_women.html).

The girls learned that, while their numbers are still small (the Information Technology Association of America reports that women hold just 25% of all professional IT positions), women bring invaluable skills to technology organizations, and their research convinced them that many women executives excel in these areas. Taking their cue from a study of professional women who have changed power structures in the corporate world by using the methods of networking and mentorship, the young women implemented these important lessons about networking—both figuratively and virtually.

An idea began to develop about a workshop that could be shared with both younger girls in their district and other interested audiences by way of an online mentorship. To facilitate this process, teacher Jeri Groves used Nicenet (http://www.nicenet.org), which is free to educators and their students, to set up a virtual classroom that enabled the girls to have discussions and exchange group ideas. After conducting independent online studies of female pioneers in science and technology, the older girls read and discussed the implications of qualitative studies of eminent women (Kerr, 1994; Reis, 1998). This activity served to refine their focus in order to brainstorm effectively the most useful applications during their planning session for the new mentor program. Finally, they began the development of a broad range of activities to "hook" the younger girls. They decided to introduce the program with a PowerPoint presentation they developed to highlight the achievements of eminent female scientists and technology pioneers and to underscore the salient fact that "Science, Math, Engineering, and Technology Can Be Fun!"



These young mentors followed the advice of Sherry Turkle, a member of the American Association of University Women's Commission on Technology, Gender, and Teacher Education and contributor to the report *Tech Savvy: Educating Girls in the New Computer Age* (Wellesley College Center for Research on Women, 2000). Turkle, a professor of sociology at MIT, believes that girls are critical of computer culture, rather than computer-phobic, and that we must make the computer culture more inviting to girls by demonstrating that technology can be used as a tool to solve real-world problems and aid human discourse. Additionally, the study carried out by Turkle found that girls should be encouraged to engage in "tinkering activities" and "artistic play" (Wellesley College Center for Research on Women, p. 10).

The Milton High students made their technology culture more inviting during the course of the mentorship as they tinkered with colorfully designed messages drawing from a repertoire of HTML code. They designed flashing marquees with encouraging affirmations, buttons created to elicit pop-up messages, text fashioned in hot pink, and shadow effects. The artful play led one young mentee to write to her mentor, "You teach me a lot! In a month, I'll be an HTML wiz!" Bulletin board conferencing took place, where the girls traded Web sites and shared discussions on everything from hurricane tracking, to frog dissection via virtual reality, to experiments conducted with "Bob, the Ex-Lab Rat." In time, interest in technology increased dramatically for both groups of girls, as did their knowledge of some of the reasons that girls lose interest in math, science, and technology.

Progress Made and Lost

While the overall news is generally positive about the gains made by girls in math and some areas of science during the 1990s, little progress has been made in the area of technology and engineering. In fact, a National Science Foundation (NSF, 2000) report detailed the problem clearly: "at all levels of education and in employment, women are less likely than men to choose science and engineering fields" (p. xi). Although the number of women receiving degrees has increased in some areas of science and math, bachelor's degrees granted to women in computer science have actually decreased from 37% in 1984 to 28% in 1996 (NSF). High school girls still take fewer higher level math and science classes, and data from the 2004 SAT test indicates that only 16% of all of those who expressed an interest in pursuing engineering and only 14% of those interested in computer or information sciences were female (Educational Testing Services, 2004). This means that many female mathematics and technology students may have less interest or encouragement to pursue technology, math, or science than their male counterparts. The problem may be even worse for academically talented girls, who often fail to perform at levels that match their potential (Reis, 1998), particularly after they leave high school.

What do we know about girls and their declining interests in math, science, and technology and how does that relate to how teachers can encourage girls in these areas? While half of the new jobs available in the next two decades will be in the new fields of technology (Jukes, 1997), women's participation in computer sciences has actually decreased over time (Wellesley College Center for Research on Women, 2000). The fastest increasing employment needs for the next two decades in our country are the areas of computer engineering, programming, and design, and girls need to get involved as early as possible in order to become interested in these areas (Green, 2000). Instead, some recent research indicates that the opposite is happening. Video games are usually a student's first contact with technology (Mackereth & Anderson, 2000), and some girls have negative impressions of the types of games they see their male siblings and friends playing. Gender differences in attitude toward computers disappear, however, when students can identify with the characters in the software (Volman & van Eck, 2001), which suggests a need for more software that appeals to girls.

Currently, fewer girls than boys learn and use technology skills at home or in school, and computer use and computer exposure time differs for boys and girls, as boys have been found to monopolize computers, even when they are in preschool (Nelson & Watson, 1991). When boys and girls are paired together at the computer, research has found that a girl will defer to her partner's wishes (Volman, 1997). Other research indicates that, by the third or fourth grade, girls are less technologically oriented than boys (Nelson & Watson, 1991).

This trend can be changed, however, as the more experience students have, the less anxiety and the more positive response they have to technology. Since boys are more likely to have access to a computer and exposure to computer games at home (Mark, 1992) and are three times more likely to be involved with computers during their secondary and postsecondary years (Kramer & Lehman, 1990), teachers must help girls increase their experiences in technology. Teachers who do not realize this may unintentionally contribute to inequity because of a lack of awareness of the positive actions they can take.

When earlier studies found gender inequity in computer education, it was first thought that the negative attitudes found in girls were toward computers in general. However, researchers did not consider learning-style differences (Volman, 1997) between boys and girls. For example, boys may have a higher initial comfort level when using computers, while girls need more training to increase their comfort level (Vernon-Gerstenfeld, 1989). Also, girls tend to have less interest in how computers or programming works, and instead

want to know how to use computers in ways that apply to their lives (Green, 2000).

Too many girls believe that work in the technology field involves sitting in front of a computer screen all day (Green, 2000), and the ideas they formulate based on their experiences in computer courses affect their confidence and self-efficacy regarding technical and scientific abilities with computers. Some researchers have suggested that girls want to feel a personal connection to the subject matter they are learning or see the usefulness of it (Belensky, 1986; Rosser, 1989). Confidence and self-efficacy, in turn, are likely to be related to whether young women continue to take computer courses. Boys may feel competent in using computers because of internal factors such as ability and effort. Girls feel less confident in their computer ability and may hesitate to claim proficiency (Volman, 1997). Girls may attribute any problems to their own failures and their successes to external factors such as luck (Reis, 1998; Volman).

During the past 15 years, most school districts have made significant investments in purchasing technology, and it is a rarity today to find a school that does not have some type of computer technology available to students. Teachers often recognize the importance and impact of the technology revolution and have worked it into the curriculum. Girls, however, tend to shy away from technology courses because of a lack of interest (Volman, 1997). The more advanced the level of computer courses, the larger the gender gap becomes. Gender differences are not as prevalent when computers are used for word processing or computer-assisted instruction (Mark, 1992). With little to encourage them, girls usually use computers as a tool for word processing and communicating with their friends (Kramer & Lehman, 1990; Wellesley College Center for Research on Women, 1998), while boys more often use computers for higher level tasks such as programming and in computer application courses in graphic arts and computer-aided design (Volman; Wellesley College Center for Research on Women).

Interest in math, technology, and science must be stimulated for girls, as high school girls cite an absence of interest as the reason fewer girls participate in computer classes (Volman, 1997). Unfortunately, advanced classes may not help peak interests. In a study with 455 adolescents, boys indicated higher levels of enjoyment with technology both before and after such a course (Mackereth & Anderson, 2000). The Wellesley College Center for Research on Women (2000) reported that girls dislike computer programming classes because of the narrow technical focus and found that girls do not pursue computer courses in high school because they are critical of the computer culture, rather than the mistaken belief that they are computer-phobic. To address this lack of interest, teachers can work to design gender-inclusive instruction to teach computer education in a way that is both effective and attractive to girls (Volman), as Carol Graham did.

Web Sites Dealing Specifically With Gender Issues in Mathematics, Science, and Technology

Biographies of Women Mathematicians
http://www.agnesscott.edu/lriddle/women/women.htm
This site provides extensive biographical information on women mathematicians, as well as some photographs.

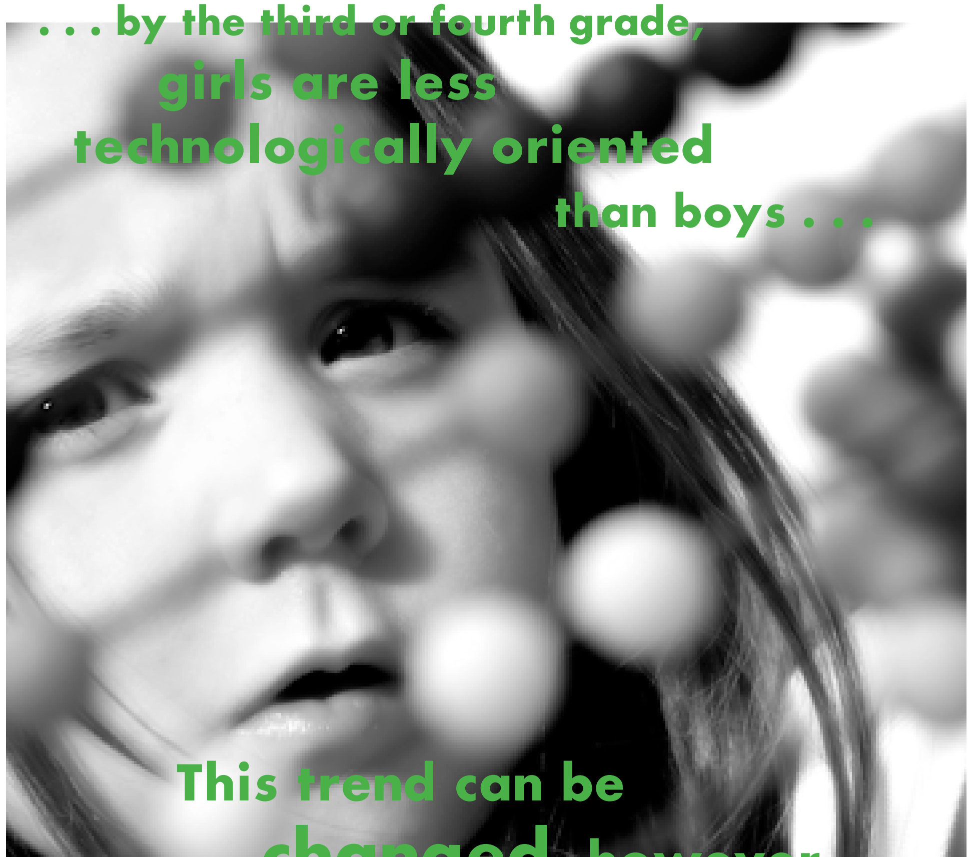
TeacherTECH
http://teachertech.rice.edu
This site focuses on girls being shortchanged in computers and technology.

Girls: Math and Science Achievement
http://www.maec.org/girlmath.html
This site provides information on math and science achievement for girls.

Closing the Gap
http://www.terc.edu/mathequity/cg/html/cg-home.html
This site provides extensive information on using math clubs for girls.

Specific Strategies

Teachers can implement specific strategies to help girls succeed in technology. Girls in the upper elementary or middle school grades are at a particularly critical point in their scientific, mathematical, and technical development. When teachers create environments that nurture and encourage, they offer support and confidence to girls who may be interested in advanced opportunities in math, science, and technology (National Council of Teachers of Mathematics, 2000).



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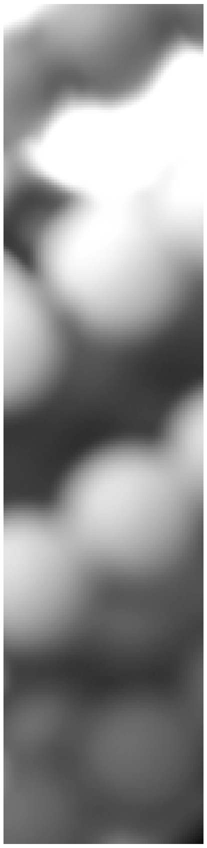
Teachers play a critical role in encouraging girls in these areas by acting as role models and creating a psychologically safe environment that is conducive to all students' learning. For example, Rogers (1990) found that teachers who made significant progress in attracting talented females to higher level mathematics courses created open and supportive classroom environments for all students. Gavin (1996) found that almost half of the female mathematics majors at a very competitive college attributed their decision to major in mathematics to the influence of a high school teacher, specifically someone who maintained a personal relationship with his or her students throughout their college years.

To improve the climate for teaching mathematics, technology, and science, teachers must analyze their own feelings about these content areas. If they feel fear, dislike, or ambivalence, their teaching may inadvertently reflect these feelings. Fear or dislike of technology may be reflected in preferences in their teaching, curriculum, and classroom activities.

Adolescent girls, particularly those with talents in mathematics, science, and technology, may receive mixed messages from parents, peer groups, and their teachers. These students need specific encouragement to help them believe that they have potential in these areas and to encourage them to pursue these areas in high school, college, and beyond. In particular, they need to be encouraged to pursue continued studies in the field and to enroll in and complete advanced technology and computer classes (Reis, 1998). All students, especially adolescent girls, need classrooms in which they will be heard and understood, and where they can discuss ideas. The teacher should provide a setting where "think time" is provided. Watching to see that computer access is fairly divided is also essential, and teachers should provide equal time to girls and boys for high-tech computer activities (Nugent, 2001).

Some research (Reis, 1998) has indicated that girls may have optimal learning opportunities in math, science, and technology in small groups with other girls. In coed groups, boys may dominate, becoming the leaders in the group and monopolizing the discussion, while girls become the recorders of the discussions. This is especially true in computer work, for boys may demand and use the keyboard far more often than girls. Encouraging girls to work together in pairs can help to provide more access. In addition, some single-sex class environments may help girls to excel in these areas. At Westover School, an independent all-female school in Connecticut, efforts have been made for a decade to encourage girls in math, science, and technology, and last spring, 44 of 48 Westover seniors took the Advanced Placement calculus exam. According to Ann Pollina, the principal of the school, a common question for girls at the school is, "How do I get into AP Calculus?"

Opportunity for single-sex study does not have to be limited to girls' schools, however, as many public and independent coeducational schools offer math, science, and technology clubs for girls, computer camps for girls, and summer programs for girls that enable the exploration of these areas in supportive environments. Some teachers have created all-female Math Olympiad teams, MathCounts teams, and clubs that have worked well (Volpe, 1999). Establishing opportunities for girls as after-school or activity-period alternatives pro-



vides the freedom to confront math and technology anxiety, if they exist, and to delve into complex problems in a friendly environment (Karp & Niemi, 2000). Female role-models in various math-related professions can be guest speakers at the club meetings, and field trips can be taken to explore career options that may inspire a budding mathematician.

Efforts must also be made to have technological proficiency embedded into all content areas in school. Once students and teachers understand how to use technological tools for data gathering and analysis, product development, and other advanced research purposes, it will be regarded as an essential learning tool for all students. Using alternative assessments can make a difference, too. In designing science, math, and technology curricula, teachers should include a variety of alternative assessments. As some students may not do their best thinking during timed tests, other options can enable them to demonstrate their knowledge and competencies in various ways.

Independent and/or small-group projects, Type III in Renzulli's Enrichment Triad Model (1977), can provide an ideal medium to showcase technological talent. These projects should go beyond a typical term paper and focus on investigative activities in which students assume the role of firsthand inquirers—thinking, feeling, and acting like practicing professionals. In a widely used enrichment programming option for talented students, student products are used as the vehicle to help develop research skills and provide an opportunity to use authentic methods of inquiry. Technology can be used to aid data gathering and analysis, as well as development of student products. Using this system, teachers serve as facilitators, pointing students in the direction of resource persons and materials as needed or providing direction in learning methodology to conduct the investigation.

Teachers should also work to provide female role-models and mentors, as Mary Ellen Burrell, teacher of academically talented students at Milton High School, did. In her introduction to the lesson titled "In Search of a Virtual Mentor," she inspired the young women by recounting the struggles of chemist Rosalind Franklin, after which they were eager to find more courageous stories of unsung heroes. Yet, role-models need not all be historical, as examples of women currently working in the fields of mathematics and science—mathematicians, astronauts, engineers, physicists, and astronomers—can be studied, as well. The Internet is an exciting medium for students that enables them to study and contact such professionals. The girls in the Milton High School gifted young women's seminar prepared for their mentorship workshop by exploring little-known facts about eminent women in science and technology through an search of the Web site Distinguished Women of Past and Present. At this site, they found categories ranging from computer science to engineering, with links to other Web sites devoted to women's stories of pioneering the way for all women who would pursue careers in the fields of science and engineering. Carol Sue Flinders (1998) captured the powerful lesson inherent in this exercise when she discussed Gerda Lerner's important work in women's history as it relates to women's emancipation: "In other words, when a woman is about to break away from cultural norms for women—to build a house, run for president, break a horse—learning that even one other woman has done it successfully brings that act into the realm of possibility after all; it has, indeed, what economists call a multiplier effect on the likelihood that she'll actually do it" (p. 7).

Leppien (1995) advocated the study of literature that reports gifted women's lives and works as a much-needed strategy for developing strong, empowered young women. She suggested the use of bibliotherapy to provide gifted females with modeling of problem-solving situations similar to ones they encounter. Milne and Reis (2001) also reported that videotherapy using films that highlight the accomplishments of women can play the same role as bibliotherapy. In the Milton High mentorship program, as each teenage scientist shared her findings with the rest of her cohort, she explored the narratives surrounding the pioneer's sense of destiny and commitment to the path of her work, important choices the pioneer made while accomplishing her goals, and how the pioneer inspired the student as "a pioneer-in-the-making."

A rewarding experience for teachers, as well as girls, is organizing and participating in a career day in technology. At these conferences, often held for girls in middle or high school, female professionals conduct hands-on workshop sessions with girls, interacting with them and exposing them to actual on-the-job activities. One of the greatest benefits from these interactions with profes-

sional women is the opportunity for establishing mentorship and internship programs. Participating in these programs gives girls with interests in mathematics, science, and technology the opportunity to work directly with a female role-model in a related career position.

Finally, teachers may create a powerful intervention to gender inequity in science, math, and computer education by providing opportunities for older female students to mentor their younger female counterparts. The teachers in the talented and gifted program at Milton High School observed that their students undoubtedly reaped the most benefit from the mentorship adventure and recognized that their evaluation of these experiences echoed two important concepts consistently appearing in the literature on gifted girls (Brown & Gilligan, 1992; Reis, 1998). First, a powerful means by which gifted young women may rediscover their voices after losing them in middle school is in remembering those voices through the mentoring of younger girls. Second, gifted girls gained confidence when their peers were successful, and even more confidence was gained by creating a reservoir of successful personal performances. Many memories of these past successes are drawn upon, and thus reinforced, as older gifted females mentor younger gifted girls.

The young women from the Milton High mentorship program came to the planning seminar with a strong sense of mission. They spoke clearly about their hopes for helping the younger girls make their way from elementary school to middle school easier by giving them a glimpse of what they have waiting for them when they get to high school. During their preplanning sessions, they reflected back on their own time in fourth and fifth grades as being the last time they remembered feeling truly free and unselfconscious. The high school students indicated that, in middle school, they cared too much about what others thought about their actions and seemed to lose that sense of passion for throwing themselves into interests such as science and technology. It wasn't until they reached high school that they began to believe that they could venture into those domains again.

Yet, every high school girl came back from the mentorship program amazed at the strong voices and emphatic dreams expressed by the elementary girls throughout the day's activities. This revelation is not entirely surprising: Lyn Mikel Brown and Carol Gilligan (1992) reported similar discoveries made by researchers of the Harvard Project in the Laurel School setting, implying that "adolescence is a time of disconnection, sometimes of dissociation or repression in women's lives, so that women often do not remember . . . what as girls they have experienced and known" (p. 4). As the Harvard researchers heard these struggles reported in their young participants' narratives, they "began to know what we had come not to know" (p. 4).

The second important finding was addressed by Reis (1998) as the critical need for gifted women to develop a strong sense of self if they are to realize their gifts. Reis discussed the importance of the psychological construct of self-efficacy in outlining measures to ensure self-efficacious women: verbal persuasion from both parents and friends, visibility of role-models like themselves, and—most important of all—opportunities to produce vital work to create a portfolio of past successful performances. One Milton High School mentor summed it up at the end of her second year's workshop:

> I think the Sci Tech Chicks seminar and mentorship workshop is a great help with girls—yes, even high school girls—who are not so certain as to whether or not they should go into a certain field because it's not typical. . . . It's nice to level the playing ground. . . . It was amazing to see how many of those [elementary] girls are interested in pursuing careers that aren't historically associated with women. . . . I think that, if those girls are supported in their goals along the way, then they have a better chance of eventually fulfilling them—and I realize that I do, too!

Conclusion

Fewer girls have interests in mathematics, science, engineering, and technology and pursuing careers in related fields. Intended to promote equality, the majority of the strategies suggested in this article have focused on constructivist, conceptual learning and encouraged positive teaching techniques designed to help both girls and boys in communities of learners. Only the wider use of these strategies will provide answers to questions about how we can continue to recruit the number of students talented in mathematics, science, and technology our nation needs in the future. What should be clear to all of us is that fewer girls regard a career involving mathematics or technology as an attainable goal, and it is vitally important to encourage and support more

girls to pursue these areas in the future. GCT

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